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Ecological Indication, Bioaccumulation, and Phytoremediation as Tools for Environmental Quality Management

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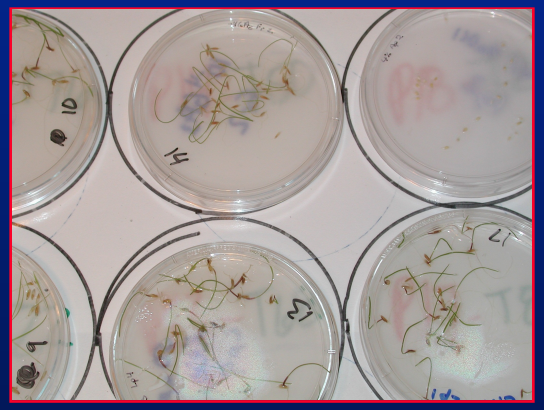

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Contamination of Confined Disposal Facilities

Many areas exist that are contaminated by man-made activities.

Examples of such areas that came into existence by activities of the Corps of Engi since the mid-sixties are Confined Disposal Facilities for dredged material.

Heavy metals and recalcitrant organic compounds, such as PCBs, PAHs and PCDDs have drawn attention as potential threats to ecological and human health.

Prior to dredging, the sediments are chemically characterized, and the decision to preset part of the total volume of dredged material into a CDF is based on these c results.

After placement of the dredged material in the CDF, however, considerable uncert as to:

1. Where the contamination is,
2. What the levels are, and
3. Whether the contamination accumulates in the plants and animals colonizing the CDF, and how the CDF can be managed in such a way that contaminant tra biotic vectors can be minimized

Contamination of Confined Disposal Facilities-ctd 2

Many CDFs are nearing or exceeding design capacity.

<u>For the near future the following trends are noticeable:</u>

1. **Continued demand for CDFs to manage contaminated sediments for navigati**
2. **Increased demand for CDFs to manage contaminated sediments dredged for**
3. **More stringent environmental requirements for new CDFs**
4. **Considerably increased costs of new CDFs due to inflation**
5. **Fewer ports and local governments are capable of sponsoring a new CDF**

<u>Options to increase the capacity of the CDFs are:</u>

1. **Raise the elevation of the surrounding dikes**
2. **Increase consolidation of dredged material in the CDF through dewatering**
3. **Remove material from the CDF after suitable treatment (sediment remediati completed or initiated at > 30 sites in the Great Lakes area; USEPA 1998).**

Potential Usefulness of Plants and Animals in Toxicity Assessment, Management, and Treatment of Contaminated Areas

The use of suitable plant and animal species, ecological indicators, can be of great assessing the toxicity and bioavailability (mobility) of contaminants.

Furthermore, the use of suitable plant species can be of great help in the manage contaminated soil/sediments by preventing contaminants to leave the area in the runoff, leaching, or dust particles by complexation or compartmentation in the rhiz and influencing the hydraulic conductiveness of the soil (phytostabilization).
Plants can also play an important role in the treatment of contaminated soils/sedi by uptake and subsequent destruction of (organic) contaminants, thereby lowering toxicity of the substrate (phytoextraction).

Example of Using Ecological Indicators for the Assessme of Toxicity and Bioavailability of Metals

Case: **Monroe, MI, CDF**
Test organisms: **Plants,** *Yellow nutsedge*
Bermuda grass
Invertebrate, *Eisenia fetida*

Results Phytotoxicity

The Monroe soil did not exhibit a significant phy
effect. The variability in growth response was at
partly to non-synchronous initiation of growth
Both species behaved differently.
For both plant species the magnitude of the effe
depended on the test duration. *Yellow nutsedge* **pr**
signifiantly more root biomass in small than in la
Bermuda grass **produced significantly more shoot**
in large than in small pots

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Plant Experiment

Results Bioaccumulation of Metals

Species	*Yellow nutsedge*		*Bermuda grass*	
	Shoot	Root	Shoot	
Metal				
Lead		0	+, ≥ 63 d	-
Nickel	+, s	+, s	+, s	
Vanadium	0	+, ≥63 d		0
Zinc*	+, s	+, s	+, s	
Mercury		0	0	0

+, present
0, absent
-, does not accumulate
s, statistically significant accumulation
* Tends to decrease with time

Worm Experiment

Results Ecotoxicity: Metals:

Effect on worm biomass (g DW of 20 specimens) not significant in period up to 65 d. Effect on coccoons not significant after 28 d.

Results Bioaccumulation of

Species	*E. fetida*
Metal	
Lead	0
Nickel	0
Vanadium	0
Zinc*	+ ≥ 12 d
Mercury	+ ≥ 65 d, s

+, present
0, absent
-, does not accumulate
s, statistically significant accumulation
* Tends to decrease with time

Summary Assessment of Toxicity and Bioavailability (m
of Contaminants Using Ecological Indicators

Dredged material: many contaminants, in low concentrations

Ecological indicators:

Plants: Dredged material not significantly toxic

Bioaccumulation of Pb, Ni, SB, Zn in *Yellow nutsedge*

Bioaccumulation of Ni, Zn in *Bermuda grass*

Invertebrates:

Dredged material not significantly toxic

Bioaccumulation of Zn, Hg in *Eisenia fetida*

Conclusions: (1) Dredged material not directly toxic for test plants and worms

(2) Of the metals present, Pb, Ni, Sb, and Zn show potential for mobili on/off site through plants

(3) Of the metals present, Zn and Hg show potential for mobility on/o site through worms

Phytoremediation

Three different processes involved:

1. Phytostabilization
2. Phytoextraction (incl. rhizofiltration)
3. Plant-assisted bioremediation

Contaminant groups and most useful phytoremediation applications:

1. Organics
   - Explosives
   - PCBs, chlorinated solvents
   - PAHs
   - Remediated by phytoextraction and/or plant-assisted bioremediation
2. Metals
   - Essential elements for plant growth (Fe, Mn, Zn, Cu, Mg, Mo, Ni)
   - No known biological function (Cd, Cr, Pb, Co, Ag, Se, Hg)
   - Managed by phytostabilization; to less extent remediated by phytoextraction

Phytoremediation

Steps required for successful application of phytoremediation:

1. Screening of plants for contaminant tolerance (contaminant type an
   - taking geographical distribution and potentially invasive behavior
2. Determination of rate of contaminant immobilization, uptake, and c
3. Determination of contaminant compartmentation
4. Scaled-up application of bench-scale findings (field demonstration, or/and fu

Phytoremediation research at the EL-ERDC covers all these steps

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